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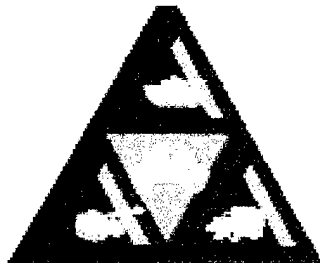
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Technical Report

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Market Investigation for Advanced Engine and Powertrain Lubricants

August 2001

Allen S. Comfort

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**U.S. Army Tank-
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13. ABSTRACT (Maximum 200 Words) <p>The design of the Future Combat Systems (FCS) and Interim Force are expected to push the envelope of the capabilities of current military engine and powertrain lubricants. These vehicles are expected to have high heat soakback due to limited space constraints, increased power density, and increased range requirements. Current military engine and powertrain lubricants simply cannot perform under the high temperatures, loads, and range that future combat systems will demand.</p> <p>In response to this need, a market investigation was conducted by the Fuels and Lubricants Technology Team (FLTT) of the Tank-automotive Research, Development and Engineering Center (TARDEC) in Warren, MI. The purpose of this market survey was to gather data on both commercially available and developmental advanced engine and powertrain lubricants.</p> <p>Based on the submission of the market survey questionnaires and a limited literature search, there is a possibility that commercial or developmental advanced engine and powertrain lubricants may 1) provide fuel consumption savings on the order of 1-5%, 2) reduce maintenance and downtime by extending drain intervals as much as four times conventional oil drain intervals, and 3) retain adequate oxidation and thermal stability at higher sustained oil sump temperatures (> 300°F).</p>				
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Contents

	Executive Summary	ii
Section 1	Introduction.....	1
Section 2	Background	2
Section 3	Survey Approach	4
Section 4	Results.....	5
Section 5	Conclusion	11

Tables

Table 1	Summary of Market Survey Questionnaire Results.....	T-1
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Appendices

Appendix A	Addresses of Companies.....	A-1
Appendix B	Commerce Business Daily Announcement	B-1

Disclaimer:

This report is provided for information only. It does not serve as an official endorsement of or indictment against any of the products mentioned. Every effort has been made to identify manufacturers of lubricants which may contribute to the overall goals outlined in the report, including posting an announcement in the Commerce Business Daily in April 2001. The report was based upon information submitted in the Market Research Survey provided by lubricant manufacturers and other sources, including lubricant suppliers and distributors.

Executive Summary

This report documents the results of a market survey on advanced tactical engine and powertrain lubricants for the U.S. Army's diesel powered equipment. The scope of the project includes both commercially available and experimental lubricants. The survey was conducted by the Fuels and Lubricants Technology Team (FLTT) at U.S. Army Tank-Automotive Research, Development and Engineering Center (TARDEC) in Warren, MI. Eleven companies submitted market survey questionnaires offering over twenty-five products including: seven engine oils, three gear lubricants, two transmission fluids, four greases, four aftermarket additives, four viscosity modifiers, and one base oil.

This market research revealed that there are a number of different commercially available lubricants with the potential to contribute to increased fuel economy, extended drain intervals, reduced maintenance, and performance at higher engine and powertrain oil sump temperatures (> 300 °F). These improvements will be key to enabling the U.S. Army's future combat systems (FCS) to be the most highly mobile, highly deployable, and lethal ground force in the world.

Section 1 - Introduction

OBJECTIVE

The objective of this market survey was to gather data on both commercially available and developmental advanced engine and powertrain lubricants. This data will be used to determine whether current commercial and/or developmental lubricants are available which will help the U.S. Army meet the needs of its Science and Technology Objective (STO) for advanced fuels and lubricants.

SCOPE

The scope of this market survey is primarily focused on engine and powertrain lubricants that will help meet the overall goals of the U.S. Army's Science and Technology Objectives (STO) for advanced fuels and lubricants. In particular, advanced engine and powertrain lubricants will help achieve the following goals:

1. Increased fuel economy
2. Reduction of required maintenance (i.e. extending oil drain intervals, reducing wear, etc.)
3. Adequate performance at higher engine and powertrain oil sump temperatures (> 300° F)

Section 2 – Background

MILITARY REQUIREMENT

The Future – The Future Combat System (FCS) is generally described as the primary new weapon and troop-carrying platform(s) for the Army's planned Objective Force. This force will be required to be smaller, lighter (< 20 tons), faster, and have greater operational range¹. The key enabling technologies for the FCS will include lubrication intense technologies such as low heat rejection (LHR) diesel engines, compact hydrostatic pumps and motors, high temperature friction materials and advanced ceramic wear coatings. The common thread between all these FCS enabling technologies will be the need for advanced lubricants offering special protection in the areas of high temperature stability, low deposit formation, and reduced friction and wear between traditional materials and the new advanced materials used in future combat vehicle powerplants.

The Interim – The Interim Force are those combat systems that are currently being fielded or retrofitted and will fill the operational needs between the present and the introduction of the FCS. From a lubrication standpoint, the interim force is a very unique system that combines the traditional needs of the legacy systems with the increasing demands of newly developed and fielded systems. These newly fielded systems are the first steps towards the FCS concept. They incorporate many of the technological innovations required by the FCS, including, compact engine and powertrain designs with limited room for cooling and the introduction of new emissions control systems. These new designs are pushing the envelope of the current military engine and powertrain lubricants and are subsequently eliminating the built in safety factors which have traditionally protected the system during those rare situations when the system is required to operate outside the original concept of the design.

The Legacy – The Legacy Force are those combat systems that have been for many years and are still an integral part of the Army's combat vehicle system. The challenge is to provide for this systems' lubrication needs while the changing technology of the FCS and Interim force demand characteristics that are not necessarily backward compatible with the lubrication requirements of the legacy systems.

The Mission

The TARDEC Fuels and Lubricants Technology Team is committed to providing the soldier with the most advanced technology available. We feel that innovation is the key to a superior Army and we are working hard to bring advanced lubricants to the soldier. In the end different generations of Army ground combat vehicles and other systems will need to operate seamlessly together on the field of future combat. Having the right lubricants at the right time will be fundamental for the success of this integration. Regardless of the system generation, advanced engine and powertrain lubricants will increase survivability and reduce logistics burden. Advanced lubricants that perform at higher temperatures will allow for improved deployability by reducing cooling system footprints and increasing the power density of engine designs; reducing the size and weight of the combat system. These new designs will in-turn allow for greater acceleration and speed which will increase survivability and lethality of the system. Advanced lubricants that reduce friction and wear contributing to less downtime and higher fuel economy will allow for increased operational range and lower emissions. Finally, advanced

Section 2 – Background

lubricants that operate over a wider range of ambient temperatures will reduce the number and type of different lubricants required allowing for a much reduced logistic burden.

Section 3 – Survey Approach

The purpose of the market survey and questionnaire was to obtain information on the current status and availability of advanced engine and powertrain lubricants meeting the goals outlined in Section 1, under Scope.

IDENTIFICATION OF COMMERCIAL SOURCES

The process for identifying potentially interested commercial sources of advanced engine and powertrain lubricants included the use of several resources such as the Lubes'N'Greases 2000-2001 Lubricants Industry Sourcebook, internet searches, and several presentations to attendees of the Lubricants Review Institute (LRI) meetings for the qualification of engine and gear oils. Furthermore, a Commerce Business Daily (CBD) announcement was posted in April 2000 (see Appendix B).

DATA COLLECTION

Based on the results of the identification phase, potential companies were contacted and informed of the market survey questionnaire found in the CBD. Interested representatives were invited to TACOM to discuss the Army's STO on advanced fuels and lubricants and how their technology would help meet the goals stated in Section 1, Scope. The identification phase and data collection took place from November 2000 to June 2001. Advancements in lubrication, engine, and powertrain technology are constantly occurring, so exploration of new advanced engine and powertrain lubricants is an ongoing process.

Section 4 – Results

A brief summary of the market survey questionnaire results is shown in Table 1, and is taken from information submitted by each company and/or representative. In order to protect company proprietary information and data, only selected information has been provided.

The following product descriptions are a summary of the information provided in the questionnaires and by no means, represent a comprehensive listing of the data provided. Liberty was taken in distilling the information provided into its key elements that pertain to the goals of the STO as listed in the Scope of this report. Every attempt has been made to ensure the accuracy of the data presented.

Advanced Engine and Powertrain Lubricant Candidates

American Synthol, Inc. is a small business that has been producing lubricants since 1983. They purchase base stocks and additives to blend finished lubricants. Their products include synthetic and semi-synthetic air compressor lubricants, heavy-duty gasoline and diesel engine lubricants, gear lubricants, refrigeration compressor lubricants and specialty lubricants. For the purposes of the survey American Synthol, Inc. has offered the following products:

- **Eagle G4 Super Premium Synthetic Engine Lubricant** – This synthetic engine lubricant comes in three viscosity grades: 5W/30, 5W/40, and 10W/50. Eagle G4 is claimed to meet or exceed the requirements of API SH/CH-4, Caterpillar TO-2, Mercedes Benz 227.5 and 228.3, Mack EO-K/2, MAM 271, Cummins NTC-400, Allison C-4, CCMC D-4/G-5/PD-2, and MIL-PRF-2104G specifications (Note: This product is not qualified under MIL-PRF-2104G). The information submitted suggests that this engine lubricant will improve fuel economy and reduce scheduled maintenance by extending oil drain intervals. Testing data submitted included typical physical and chemical properties, chassis dynamometer evaluation, oil analysis, and fuel economy comparisons.
- **ATF III Super Premium Synthetic Transmission Fluid** – This is a fully synthetic automatic transmission fluid. ATF III claims to exceed the requirements of every automatic transmission builder. The information submitted suggests that this fluid will improve fuel economy and reduce maintenance. Testing data submitted included typical physical and chemical properties.
- **SGL-Auto Super Premium Synthetic Gear Lubricant** – This is a fully synthetic gear lubricant and is available in two viscosity grades, 75W/90 and 80W/140. SGL-Auto is claimed to meet and exceed the performance requirements for API GL-5 and MT1, Rockwell International (0-7-e), MIL-PRF-2105E (Note: This product is not qualified under MIL-PRF-2105E), Mack GO-G/S and GO-J Plus, and Eaton AXLED1UPS-109. This product also claims to perform in limited slip differentials. The information suggests that this gear lubricant will reduce downtime and maintenance costs, and provide extended drain intervals. Testing data submitted included typical physical and chemical properties.

Section 4 – Results

Bell Additives, Inc. is a small business and has existed since 1909. They primarily manufacture gasoline and diesel aftermarket engine oil additives and fully formulated greases. For the purposes of the survey Bell Additives, Inc. has offered the following products:

- **X-TRA Lube Concentrate and X-TRA Lube Pre-Mix in oil** – This product is an aftermarket oil additive for use in automotive and stationary engines, gear boxes, hydraulic systems, compressors, bearings, and manual transmissions. The information submitted suggests that the use of X-TRA Lube Concentrate will reduce friction and wear thereby providing reduced maintenance, reduced emissions, and increased compression. No testing data was submitted for this product.
- **X-TRA Lube Grease** – This is a lithium based-soap complex grease, NGLI Grade 2. The information provided suggests that this product will reduce friction and wear, and has both excellent high and low temperature characteristics. Testing data submitted includes typical physical and chemical properties and bench test results.

Castrol Lubricants is large business and has been in existence for over 50 years. They primarily supply finished lubricants and other related services. For the purpose of this survey they are working with Allison Transmission and are offering the following product:

- **TranSynd** – This product is a fully synthetic, universal powershift and automatic transmission fluid. This product is formulated for use in a variety of applications including commercial vehicles and trucks, off-highway vehicles, school buses, vans, and motorhomes. TranSynd claims to meet or exceed the performance requirements of DEXRON-III, Allison TES-295, Allison C-4, Voith Transmission and ZF Transmissions. Information submitted suggests that the use of TranSynd will increase fuel economy, reduce scheduled maintenance, extend fluid drain intervals, and protect against high oil sump temperatures. Testing data submitted included typical physical and chemical properties and high temperature oxidation test results.

Chevron Phillips Chemical Company is a large business owned 50% by Chevron and 50% by Phillips Petroleum. As a stand-alone joint venture they have been in business 1 year and over 30 years as an affiliate of Chevron. For the purposes of the survey Chevron Phillips has offered the following product:

- **Low Viscosity Polyalphaolefins** – This is a fully synthetic base oil used in the final formulation of a variety of lubricating products. It is planned that this product will be available in 1Q02. Information submitted suggests that this base oil will provide superior high temperature stability via its low volatility. No test data was submitted but data is available.

Exxon Mobil Corporation is a large corporation that has been in existence for over 100 years. They manufacture base stocks, finished lubricants and lubricant specialty products. Products produced include engine oil, transmission fluids, gear oils, hydraulic fluids, preservative oils, torque fluids, greases, and industrial turbine oils. For the purposes of the survey Exxon Mobil has offered the following product:

Section 4 – Results

- **Mobil Delvac 1** – This is a fully synthetic heavy-duty motor oil, meeting the SAE viscosity grade of 5W-40. Mobil Delvac 1 is commercially available on a global basis. Mobil Delvac 1 is claimed to be formally approved in the following specifications: API CH-4, CG-4, CF, SJ, and SH, ACEA E5-99, E4-99, E3-96 and B4-98, Global DHD-1, Cummins CES 20077, 20076, 20072, and 20071, Detroit Diesel 7SE270 (meets published requirements), and closed crankcase application TSB 01-TS-07, Mack EO-M Plus, EO-M, and EO-L Plus, MAN M3277, MTU type 3, Mercedes Benz sheet 228.5, RVI RXD, and Volvo VDS-2. The information submitted suggests Mobil Delvac 1 will increase fuel economy by as much as 4%, extend drain intervals, reduce maintenance costs, and provide high temperature oxidation stability. Test data results include testing in double length Sequence IIIF test to evaluate the protection of the engine under high oil sump temperatures, multiple engine test results include those for Caterpillar, Cummins, and Mack, and fuel economy benefit tests.

Go Marketing Inc. is a small business that was established in 1998 and supplies aftermarket fuel additives. For the purposes of the survey they are offering the following product:

- **Diesel/Gas Go** – This is an aftermarket fuel additive designed to increase fuel economy and enhance driveability. This product is not yet commercially available but is expected to be introduced in 3Q01. Although no test data was submitted at the time of writing this report, the company intends to have the required testing done as described in the DOD Policy Guidelines for Use of Aftermarket Fuel & Lubricant Additives.

Muscle Products Corporation (MPC) is a small business that was established in 1985. MPC manufactures metal treatments, friction reducers, greases, and specialty lubricants. For the purposes of the survey MPC has offered the following product:

- **MT-10 Metal Treatment** – This product is an aftermarket oil additive described as a metal conditioning formula. This product is sold commercially and has been on the market since 1995. Its recommend uses are for gears, bearings, engines, transmissions, hydraulic systems, electric motors, pumps, and any lubrication system requiring extra protection from extreme pressure, friction-related heat and high wear conditions. The information submitted suggests that this product will reduce maintenance costs and downtime by reducing wear and increase fuel economy. Test data submitted includes typical physical and chemical properties, and several tests for product corrosiveness to copper (D130 and D664), oxidation stability (D2893), and extreme-pressure antiwear properties (D2783).

RohMax Oil Additives is a small business formed in 1996, its parent companies have more than 60 years experience in developing, manufacturing, and marketing lubricant additives. They manufacture viscosity index improvers and pour point depressants that are included in the formulation of major international oil brands. For the purpose of this survey they are offering the following products:

Section 4 – Results

- **Viscoplex 6 series products** – The Viscoplex 6 series products are multi-functional viscosity index (VI) improvers particularly useful in the formulation of gasoline and diesel engine oils. This product is available commercially and claims to provide excellent soot dispersion in diesel engines therefore contributing to extended drain intervals. The polymethacrylate chemistry of the VI improver is stable at high oil sump temperatures. The test data submitted included typical physical properties and other bulk fluid data as a function of temperature.
- **Viscoplex 0 series products** – The Viscoplex 0 series products are viscosity index improvers designed for use in multigrade gear lubricants. This product is available commercially and can be used in both mineral and synthetic base fluids. In addition to the improving VI this product also claims to improve the low-temperature fluidity of the base fluids. Test data submitted includes physical properties and other bulk fluid properties as a function of temperature.
- **Viscoplex 12 series products** – The Viscoplex 12 series products are dispersant viscosity index and low-temperature fluidity improvers designed for use in automatic transmission fluids. This product is available commercially and is typically added at a rate of 5% by weight. It uses a polyalkyl methacrylate chemistry blended in a highly refined mineral oil. Test data submitted includes physical properties and other bulk fluid properties as a function of temperature.
- **Viscoplex 1 series products** – The Viscoplex 1 series products are shear-stable pour point depressant for use in engine oils, hydraulic fluids, and gear oils. These are commercially available and typical treat rates range from 0.1% to 0.3% by weight. Test data submitted includes physical properties and other bulk fluid properties as a function of temperature.

Romeo Enterprises is an independent distributor of Amsoil Inc. synthetic lubricants. Romeo Enterprises has been in business since 1994 and furnishes Amsoil synthetic lubricants including motor oils, greases, compressor fluids, and transmission/powershift fluids. Romeo Enterprises also furnishes oil filters and aftermarket fuel additives. For the purposes of the survey Romeo Enterprises offered the following products:

- **Synthetic Heavy-Duty Diesel and Marine Motor Oil** – This product is a fully synthetic motor oil and is available in multigrade 15W-40. It is recommended for use in engines used in marine applications, as well as diesel engines used in trucks, fleets, mining, earth moving, construction and farm equipment. It is commercially available and claims to meet or exceed the following requirements: API CG-4, CF-2, CF, SH, and SJ, ACEA B1, B2, E1, and E2, MIL-PRF-2104G and MIL-L-21260D (Note: MIL-L-21260D has been canceled and superseded by MIL-PRF-21260E, this product is not qualified under MIL-PRF-2104G or MIL-PRF-21260E), Caterpillar TO-2 and TO-3, Allison C-3 and C-4, Mack OE-L and OE-L Plus, M.A.N. 271, Mercedes Benz AG 227.1, 228.1, and 228.3, Scania Long Drain, Volvo VDS and VDS-2, and VW 505.00. The information submitted suggests that the use of this

Section 4 – Results

product will provide extended drain intervals, increase fuel economy, reduce emissions, lower equipment wear, and resist oxidation at high oil sump temperatures. Test data submitted includes typical physical and chemical properties.

- **Series 3000 Synthetic 5W-30 Heavy-Duty Diesel Oil** - This product is a fully synthetic product specifically designed for applications requiring diesel specifications CG-4, CF-2, and CF. This product is commercially available and claims to meet or exceed the following requirements: API CG-4, CF-2, CF, and SH, ACEA/CCMC D-4, D-5, and PD-2, MIL-L-2104F (Note: MIL-L-2104F has been canceled and superseded by MIL-PRF-2104G, this product is not qualified under MIL-PRF-2104G), Cummins NTC 400, Detroit Diesel 7SE 270, Mack OE-L and OE-K/2, M.A.N. 271, Mercedes Benz AG 227.1 and 228.1, Scania Long Drain, Volvo VDS Long Drain, VW 505.00, Allison C-3 and C-4, and Caterpillar TO-2 and TO-3. The information submitted suggests that the use of this product will provide extended drain intervals, increase fuel economy, reduce emissions, lower equipment wear, and resist oxidation at high oil sump temperatures. Test data submitted includes typical physical and chemical properties.
- **Series 2000 Synthetic 0W-30 Motor Oil** – This product is a fully synthetic product formulated for fuel efficiency without sacrificing wear protection. It is commercially available and claims to meet the following requirements: API SH and SJ, ILSAC GF-1, ACEA A-1, A-2, B-1, and B-2, Chrysler MS-6395F, Ford ESE M2C-153E, GB 4718M and 6094M, MIL-L-46167B (Note: MIL-L-46167B has been canceled and superseded by MIL-PRF-46167C, this product is not qualified under MIL-PRF-46167C), VW 505.00 and 501.00, Mercedes Benz AG 226.1, and JASO VTW Spec. The information submitted suggests this product will be stable at high oil sump temperatures and provide maximum fuel efficiency. Test data submitted includes typical physical and chemical properties and ASTM D4172, Four-Ball wear test results.
- **Series 2000 Synthetic 75W-90 Gear Lube** – This product is a fully synthetic extreme pressure lubricant engineered to meet high-load and high temperature demands of race and commercial vehicle differentials and gear-lube transmissions. It is commercially available and claims to meet or exceed the following requirements: API MT-1, and GL-2 through GL-5, MIL-PRF-2105E (Note: This product is not qualified under MIL-PRF-2105E), Mack GO-J and GO-J Plus, Chrysler MS-8985, GM 12346140, Ford M2C-192-A, Rockwell 0-76-L, and Eaton PS-037A. The information submitted suggests that this product will increase fuel economy and be thermally stable at high oil sump temperatures. Test data submitted includes typical physical properties and ASTM D4172B results.
- **Series 2000 Synthetic Lithium Complex Racing Grease** – This product is formulated with a fully synthetic base oil with a lithium complex thickener. It is commercially available and claims to have excellent high temperature oxidation resistance, anti-wear, and low friction. Amsoil series 2000 Synthetic Lithium Complex Racing

Section 4 – Results

Grease claims to meet the performance standards of NLGI GC and LB applications. Test data submitted includes typical physical properties.

Schaeffer Manufacturing Company has been in business for over 160 years and manufactures engine oils, gear lubricants, hydraulic fluids, and many other specialty lubricants including aftermarket fuel additives. For the purpose of the survey they have offered the following products:

- #221 Moly Ultra 800 EP – This product is a multi-purpose, extreme pressure grease utilizing an aluminum complex base thickener and molybdenum disulfide additive system. Schaeffer claims this product will reduce friction and wear leading to increased equipment life, less downtime, and extended lubrication cycles. Test data submitted includes typical physical properties.
- #274 Moly EP Synthetic Blend Grease – This product is a multi-purpose, extreme pressure, wide temperature range grease. It is formulated using a fully synthetic polyalphaolefin (PAO) base fluid and an aluminum complex base thickener with a molybdenum disulfide additive system. Schaeffer claims this product will reduce friction and wear leading to increased equipment life, less downtime and extended lubrication cycles. Its synthetic base oil allows its use at extreme hot and cold temperatures. Test data submitted includes typical physical properties.
- #137B Diesel Treat 2000 - This product is a multi-functional, ashless, all season fuel additive formulated for all types of diesel fuel. The information submitted suggests that this product will improve fuel economy, reduce fuel pump and injector wear, reduce the formation of deposits, and improve the fuels high and low thermal temperature stability. Schaeffer also claims that adding this product to diesel fuel before it has reached its cloud point will lower the gelling point of the untreated fuel an average of 15 °F to 25 °F. Test data submitted includes typical physical properties.

Surfaces Research and Applications, Inc. is a small, women-owned business founded in 1987. They research and develop lubricants (engine/transmission oils, grease, solid film lubricants, additives) component materials, and condition monitoring equipment for propulsion, power generation, and industrial processes. They were awarded a 1995 U.S. Army Small Business Innovation Research (SBIR) Phase II Quality Research Award for high temperature, military diesel tribology systems. For the purposes of the survey they offer the following products:

- SRL-nn and MRI-1 - These are experimental, fully formulated, synthetic diesel engine lubricating oils. They are offered in multigrade 15W-40 and monograde 15W, 30, 40, and 50 weights. These lubricants are designed specifically for high-temperature, low heat rejection engines. Selected lubricants are to be commercially available 2Q02. Information submitted suggests these lubricants will perform at oil sump temperatures well above 300 °F, have low deposit formation, low wear, and extended drain interval capabilities. Test data submitted includes internal U.S Army investigations by the TARDEC Mobility Test Operations Team.

Section 4 – Results

The American Lubricants Company is a small business and has been operating since 1933. They manufacture fully formulated, industrial-grade oil, greases and gear lubricants. For the purpose of the survey they have offered the following products:

- **Moly Ultra-Tec Gear Lube** – This fully formulated, extreme pressure gear lubricant. It is formulated with a moly additive to increase the extreme pressure and friction-reducing characteristics of the base product. It is produced in SAE grades 80, 80W-90, and 85W-140. The information submitted suggests that this product will extend gear life, extend oil drain intervals, and resist heat related break down. Test data submitted includes typical physical property data for each grade.
- **Moly Nu-Spex Multi-Viscosity Engine Oil** - This product is available in SAE 15W-40 weight only and may be used in heavy, medium, or light duty applications. The American Lubricants Company claims this product meets or exceeds the following requirements: MIL-L-2104B, MIL-L-2104C, MIL-L-2104D, MIL-L-2104E (Note: The current combat/tactical HD diesel engine oil specification is MIL-PRF-2104G, this product is not qualified under this specification), CID AA 52039, ACEA E3/D3/A3, Caterpillar TO-2, Cummins CES 20071, API SJ, SH, SG, CD-II, CE, CF-4, CG-4, and CH-4, Mack EO-M, Mercedes Benz MB228.3, GM 6048M, GM 6085M, and GM 6094M, Ford M2C153E, Chrysler MS-6395-D, Allison C-4, and Volvo VDS-2. The information submitted suggests that this product will extend oil drain intervals and decrease engine deposits and wear. Testing data submitted includes typical physical properties.

Section 5 - Conclusion

Based on the submission of the market survey questionnaires and a limited literature search, there is a possibility that commercial or developmental advanced engine and powertrain lubricants may 1) provide fuel consumption savings on the order of 1-5%^{2,3}, 2) reduce maintenance and downtime by extending drain intervals as much as four times conventional oil drain intervals^{4,5}, and 3) retain adequate oxidation and thermal stability at higher sustained oil sump temperatures ($> 300^{\circ}\text{F}$)^{6,7}.

Using the results from this market survey and further investigation and input by the TARDEC Fuels and Lubricants Research Facility (TFLRF) located at Southwest Research Institute (SwRI) in San Antonio, Texas; the FLTT will select several lubricants for further evaluation. The purpose of the evaluation will be to further investigate the performance characteristics of the selected lubricants, develop tests and methodologies for the rating of these lubricants, perform laboratory and field testing, and ultimately, introduce new specification requirements to guide the procurement of advanced engine and powertrain lubricants.

References

- ¹ Goodman, W. G., Jr. (2001). Futuristic Army Vision. Armed Forces Journal, May, 28-34.
- ² Taylor, R. I. (2000). Heavy Duty Diesel Engine Fuel Economy: Lubricant Sensitivities. Society of Automotive Engineers (SAE) Technical Paper , 2000-01-2056. Paper presented at the International Spring Fuels & Lubricants Meeting & Exposition, France, June 19-22, 2000.
- ³ Bala, V., Brandt, G., & Rollin, A. J. (2000). Rheological Properties Affecting the Fuel Economy of Multigrade Automotive Gear Lubricants. Society of Automotive Engineers (SAE) Technical Paper, 2001-01-2051. Paper presented at the International Spring Fuels & Lubricants Meeting & Exposition, France, June 19-22, 2000.
- ⁴ Jetter, S. M., Kelly, K. J., & Ragomo, M. A. (Mobil Technology Co.), Morrow, R. C.(Mobil Oil Corp.), Nycz, D. S., Karl, G. M., Gullett, D. F., Dussault, R. G., Butler, B., & Becker, T. H. (Caterpillar, Inc.) (1998). Extended Oil Drain Performance Capabilities of Diesel Engine Oils. Society of Automotive Engineers (SAE) Technical Paper , 982718. Paper presented at the International Fall Fuels & Lubricants Meeting & Exposition, San Francisco, CA, October 19-22, 1998.
- ⁵ Kennedy, S., Lohuis, J. R., Ragomo, M. A., & Richman, W. H. (1995). A synthetic Diesel Engine Oil with Extended Laboratory Test and Field Service Performance. Society of Automotive Engineers (SAE) Technical Paper , 952553. Paper presented at the Fuels & Lubricants Meeting & Exposition, Toronto, Ontario, October 16-19, 1995.
- ⁶ Frame, E. A., & Yost, D. M. (1995). Evaluation of High-Temperature Diesel Engine Liquid Lubricants. Society of Automotive Engineers (SAE) Technical Paper , 952544. Paper presented at the Fuels & Lubricants Meeting & Exposition, Toronto, Ontario, October 16-19, 1995.
- ⁷ Kozowyk, J. P. (1998). An Investigation Of The High Temperature Capability Of An Experimental Diesel Engine Lubricant Known As A-501. U.S. Army Tank-Automotive Research, Development, and Engineering Center, Detroit Arsenal, Warren, MI, Technical Report No. 13741.

Table 1 – Summary of Market Survey Questionnaire Results

Manufacturer/Supplier	Products	Commercially Available	Claimed Contribution to STO
American Synthol, Inc.	<ul style="list-style-type: none"> Eagle G4 – Super Premium Synthetic Engine Lubricants ATF III – Super Premium Synthetic Transmission Fluid SGL-Auto – Super Premium Synthetic Gear Lubricant 	Yes	<ul style="list-style-type: none"> Increased Fuel Economy Extended Drain Intervals Reduced Maintenance Costs Low Volatility/Thermally Stable
Bell Additives, Inc.	<ul style="list-style-type: none"> E-TRA Lube Grease E-TRA Lube Concentrate 	Yes	<ul style="list-style-type: none"> Reduced Friction Reduced Wear Increased Mileage Reduces Emissions
Castrol Lubricants in cooperation with Allison Transmission	<ul style="list-style-type: none"> Castrol Transynd Automatic Transmission Fluid 	Yes	<ul style="list-style-type: none"> Reduced Maintenance Costs Extended Oil Drains High Temperature Stability
Chevron Phillips Chemical Company	<ul style="list-style-type: none"> Low Viscosity Polyalphaolefin Base Oils 	Available 1Q02	Superior Volatility/Thermally Stable
Exxon Mobil Corporation	<ul style="list-style-type: none"> Mobil Delvac 1 – 5W/40 	Yes	<ul style="list-style-type: none"> Increased Fuel Economy Extended Drain Intervals Excellent Thermal Stability/Oxidation High Temp Engine Deposit Control
Go Marketing Inc.	<ul style="list-style-type: none"> Diesel/Gas Go 	No	<ul style="list-style-type: none"> Increased Fuel Economy Improved Engine Performance
Muscle Products Corporation	<ul style="list-style-type: none"> MT-10 Metal Treatment 	Yes	<ul style="list-style-type: none"> Improved Fuel Economy Reduce Maintenance Costs Reduce Equipment Downtime Reduce Friction and Wear
RohMax Oil Additives	<ul style="list-style-type: none"> For diesel engine use: Viscoplex 6 – series products For transmission use: Viscoplex 12 – series products For gear oils: Viscoplex 0 – series products For all applications: Viscoplex 1 – series Pour Point Depressants 	Yes	<ul style="list-style-type: none"> Increased Fuel Economy Reduced Scheduled Maintenance High Thermal Stability
Surfaces Research and Application, Inc.	<ul style="list-style-type: none"> SRL-nn and MRI-1 Synthetic Diesel Lubricating Oils 	Available 2Q02	<ul style="list-style-type: none"> High Temperature Operation Extended Oil Drain Low deposit, Low Volatility Improved Fuel Economy
Romeo Enterprises	<ul style="list-style-type: none"> Synthetic 15W-40 Heavy-Duty Diesel and Marine Motor Oil Synthetic 5W-30 Heavy-Duty Diesel Oil Synthetic 0W-30 Motor Oil Synthetic 75W-90 Gear Lube Synthetic Lithium Complex Racing Grease 	Yes	<ul style="list-style-type: none"> Extended Drain Intervals Increased Fuel Economy Reduced Scheduled Maintenance
Scheaffer Manufacturing Company	<ul style="list-style-type: none"> #221 Moly Ultra 800 EP #274 Moly EP Synthetic Blend Grease #137B Diesel Treat 2000 	Yes	<ul style="list-style-type: none"> Reduced Friction and Wear Reduced Downtime Extended Lubrication Cycles Increased Thermal Stability
The American Lubricants Company	<ul style="list-style-type: none"> Ultra-Tec Gear Lube Moly Ultra-Tec Gear Lube Moly Nu-Spex Multi-Viscosity Engine Oil SAE 15W/40 	No	<ul style="list-style-type: none"> Reduced Downtime Reduced Maintenance Costs Extended Drain Intervals

Appendix A - Addresses of Companies

American Synthol, Inc.

2930 Mountain Trace
Roswell, GA 30075-5000
POC: Joe T. Green
Phone: 770-552-6661
Email: amerilube@attglobal.net

Bell Additives, Inc.

1340 Bennett Drive
Longwood, FL 32750
POC: Stan Whitlatch
Phone: 407-831-5021
Fax: 407-331-1125
Email: BAI@BELLADDITIVES.COM

Castrol Commercial North America

9300 Pulaski Highway
Baltimore, MD 21220
POC: Fred Ondarza
Phone: 630-585-0379
Fax: 630-820-3430
Email: ondarzjf@bp.com

Chevron Phillips Chemical Company

1301 McKinney Suite 1008
Houston, TX 77010-3030
POC: Mark Pernik
Phone: 713-289-4386
Fax: 713-289-4925
Email: perning@cpchem.com

Exxon Mobil Corporation

3225 Gallows Road
Fairfax, VA 22037
POC: Dave Smith
Phone: 716-662-2009
Email: David_M_Smith@email.mobil.com

Go Marketing, Inc.

10 Macopin Terrace
West Milford, NJ 07480
POC: Frank Norman
Phone: 973-492-2542
Fax: 973-492-1801

Appendix A - Addresses of Companies

Muscle Products Corporation

112 Fennell Drive
Butler, PA 16002
POC: Vincent G. Crifaci
Phone: 800-227-7049
Fax: 724-283-8310
Email: Vince@mpc-home.com

RohMax Oil Additives

723 Electronic Drive
Horsham, PA 19044-2228
POC: Charles K. Dustman
Phone: 215-706-5804
Fax: 215-706-5801
Email: c_dustman@rohmax.com

Romeo Enterprises

55 Orris Avenue
Piscataway, NJ 08854
POC: Joe Romeo
Phone: 732-235-1052
Fax: 240-220-2153
Email: joemromeo@yahoo.com

Schaeffer Manufacturing Company

102 Barton Street
St. Louis, MO 63104
POC: Geary Trout
Phone: 717-566-2777

Surfaces Research and Applications, Incorporated

8330 Melrose Drive
Lenexa, KS 66214-1630
POC: Paul Sutor, Ph.D
Phone: 913-541-1221
Fax: 913-541-0748
Email: psutor@surfacesresearch.com

The American Lubricants Company

P.O. Box 696
1227 Deeds Avenue
Dayton, OH 45401-0696
POC: Robert G. Read
Phone: 937-222-2851
Fax: 937-461-7729

Appendix B - Commerce Business Daily Announcement

[Commerce Business Daily: Posted in CBDNet on April 4, 2001]

From the Commerce Business Daily Online via GPO Access[cbdnet.access.gpo.gov]

PART: U.S. GOVERNMENT PROCUREMENTS

SUBPART: SUPPLIES, EQUIPMENT AND MATERIAL

CLASSCOD: 91--Fuels, Lubricants, Oils, and Waxes--Potential Sources Sought

OFFADD: U.S. Army Tank-Automotive and Armaments Command, Acquisition Center (AMSTA-AQ-DE), Warren, MI 48397-5000

SUBJECT: 91--ADVANCED TACTICAL ENGINE & POWERTRAIN LUBRICANTS FOR DIESEL-POWERED EQUIPMENT - DATA SOUGHT

SOL N/A

DUE 060101

POC Mr. Allen Comfort (810) 574-4225DESC: The U.S. Army Tank-Automotive Research, Development and Engineering Center's (TARDEC's) Fuels and Lubricants Technology Team is seeking data concerning advanced tactical engine and powertrain lubricants for diesel-powered equipment which will help in meeting the following science and technology objectives: enhanced/alternate lubricants that will (i) provide higher fuel economy and/or (ii) reduce scheduled maintenance by extending service intervals and reducing downtime, and (iii) perform at higher engine and powertrain oil sump temperature (> 300 F). Products for which information is being submitted should, at a minimum, meet current applicable military specifications. The following is a list of specifications: MIL-PRF-2104 ENGINE OIL MIL-PRF-46167 ARCTIC ENGINE OIL MIL-PRF-2105 GEAR OIL MIL-PRF-21260 PRESERVATIVE ENGINE OIL MIL-PRF-10924 TACTICAL GREASE MIL-PRF-46170 HYDRAULIC FLUID MIL-PRF-6083 HYDRAULIC FLUID You may access these specifications by using ASSIST-Quick Search which provides direct access to nearly 100,000 full text DoD Specifications and Standards available in the DoD master repository at the ASSIST website at <http://assist.daps.mil/> Simply enter your search criteria to locate documents available for distribution by the DoDSSP website at <http://dodssp.daps.mil/> ASSIST-Quick Search does not require an account or password and makes documents available to the public free of charge. If you are unable to access the specifications electronically, Ms. Jean VanSullen can provide a copy or answer your questions about any specification. Questions regarding whether other military lubricant specifications might be included in your market research information should be directed to Ms. Jean VanSullen by telephone at (810) 574-4222 or by e-mail at vansullj@tacom.army.mil If you have a product that will contribute to meeting these science and technology objectives, we invite you to complete and submit the market survey questionnaire which may be found at the following web site: <http://contracting.tacom.army.mil/ssn/sources.htm> Please send the completed survey and any related data to Mr. Allen Comfort via e-mail at comforta@tacom.army.mil or by datafax at (810) 574-4220, or send hard copies to the following address: U.S. Army Tank-automotive and Armaments Command, Attn: AMSTA-TR-D/210 (A. Comfort), 6501 E. Eleven Mile Rd., Warren, Michigan 48307-5000. Replies to the questionnaire must be received not later than June 1, 2001. All portions of this notice and the research survey questionnaire are subject to change at any time, are in no way binding on the Government, and are not to be considered as final, established requirements. The documents furnished in response to the questionnaire are for information purposes only with the understanding that the Government is under no obligation of any kind to proceed with an acquisition in any way related to or based upon the data submitted. The Government is not asking any company to develop or supply any lubricant as a result of this survey. The Government is not requesting any interested or potential suppliers to incur any expenses concerning their review of this notice or in responding to the attached survey. Nothing contained herein should be regarded as basis upon which to seek payment, reimbursement, or other consideration from the Government. This notice is not intended as a solicitation of any proposal and submission of an "unsolicited proposal" based on these documents will not be given consideration. Defense Supply Center Richmond (DSCR) uses Qualified Product Lists QPLs to acquire lubricants for the Government. For more information on getting your product(s) on the current QPLs or if you're interested in becoming a supplier to DSCR, please see their business opportunities at the following web site:

<http://www.dscr.dla.mil/vendors.htm>. DSCR uses the Commerce Business Daily (CBD) to synopsise to acquire products. You can access the CBD web site at the following address: <http://cbdnet.gpo.gov/> We will respond to all companies completing this survey with requests for additional technical information. We are planning to prepare a report documenting the results of this market survey. We can provide you with excerpts of the report mentioning your company or its product(s) upon request. Please direct technical questions regarding this survey to Mr. Allen Comfort at (810) 574-4225; general questions or comments about this survey may be directed to Mr. Phil Lawrence via e-mail at lawrencp@tacom.army.mil or use datafax at (810) 574-7018 or call him at (810) 574-5273.

LINKURL: <http://contracting.tacom.army.mil/ssn/sources.htm>

LINKDESC: Click here to download a copy of the Executive Summary and the Market Survey Questionnaire

EMAILADD: comforta@tacom.army.mil

EMAILDESC: Click here to contact the TARDEC representative, Mr. Allen Comfort

CITE: (W-094 SN50I2L1)